ATTACHMENT 16

ZONOLITE ATTIC INSULATION REPORT

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March 19, 2003

ATTACHMENT 2

ZONOLITE INSULATION EXPOSURE STUDIES

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March 15, 2003

ZONOLITE INSULATION EXPOSURE STUDIES
March 15, 2003

EXECUTIVE SUMMARY

A series of studies were designed and conducted to evaluate amphibole asbestos exposures during specific activities in homes containing Zonolite vermiculite insulation. The activities selected for evaluation included the following.

- Cleaning of stored items in an attic with Zonolite at perimeter only
- Cutting a hole in a ceiling of a living space below Zonolite attic insulation (ZAI)
- Moving aside Zonolite attic insulation using the Grace method
- Moving aside Zonolite attic insulation using a homeowner method
- Removal of Zonolite insulation from top of wall cavities with a shop vacuum

The field work for these studies was conducted during the week of November 4, 2002 at two homes in the Spokane, Washington area. The cleaning activity and the removal of Zonolite insulation with a shop vacuum occurred in a home with Zonolite exposed at the top of perimeter wall cavities only. The other activities were performed in a home with ZAI throughout the attic space. A total of 162 personal and area air samples were collected and analyzed as part of the exposure study. Surface dust samples and bulk samples were also collected and analyzed. The results are briefly summarized below.

Activity	Worker Exposure			Area	
Evaluated	f/cc	s/cc	s/cc>5µm	s/cc	s/cc>5µm
Cleaning items in an attic	1.54	<0.42[1]	<0.42	0.08	0.07
Cutting a hole in a ceiling	5.8	2.48	1.32	0.62	0.52
Moving ZAI (Grace method)	12.5	6.29	4.85	2.30	1.85
Moving ZAI (homeowner method)	14.4	20.0	16.0	2.35	5.56
Shop vacuum removal	2.90	1.47	0.98	0.77	0.53
No activity	-	-	-	<0.003	<0.003

[1] Best estimate of worker exposure from area samples collected in the cleaning area is 0.12 s/cc and 0.11 s/cc, great than 5 µm.

ZONOLITE INSULATION EXPOSURE STUDIES
March 15, 2003

INTRODUCTION

A series of studies were designed and conducted to evaluate amphibole asbestos exposures during specific activities in homes containing Zonolite vermiculite insulation. The activities selected for evaluation included the following:

- Cleaning of stored items in an attic with Zonolite at the perimeter only
- Cutting a hole in the ceiling of a living space below Zonolite attic insulation
- Moving aside Zonolite attic insulation using the Grace method
- Moving aside Zonolite attic insulation using a homeowner method
- Removal of Zonolite insulation from the top of wall cavities with a shop vacuum

The field work for these studies was conducted during the week of November 4, 2002 at two homes in the Spokane, Washington area.

Acknowledgements

Funding for the studies was provided through the firm of Richardson, Patrick, Westbrook and Brickman of Charleston, SC from funds authorized by the bankruptcy court. The study participants are grateful for the financial support of this project. We also acknowledge Mr. Darrell W. Scott, Mr. Kelly Konkright, Ms. Kristy Bergland, and Ms. Samantha Batorson of Lukins and Annis for their assistance with the logistics necessary to conduct the work in the Spokane area.

The study design, methods used, field work, analytical work, and this report are the product of the study participants. The study participants included William M. Ewing, CIH and Tod A. Dawson of Compass Environmental, Inc.; Mr. Richard Hatfield, Dr. William Longo, and Mr. Paul Liss of Materials Analytical Services, Inc.; and Mr. Steve M. Hays, PE, CIH, Mr. Ron V. Gobbell, FAIA, and Mr. Pete Cappel of Gobbell Hays Partners, Inc.

We recognize the work by the staff of Fulcrum Environmental Consulting of Spokane for their assistance during the field work, and during the post-study remediation work that occurred. We appreciate the efforts of IRS Environmental of Spokane for their work in containment and decontamination facility construction during the field work, and remediation work at the conclusion of the project.

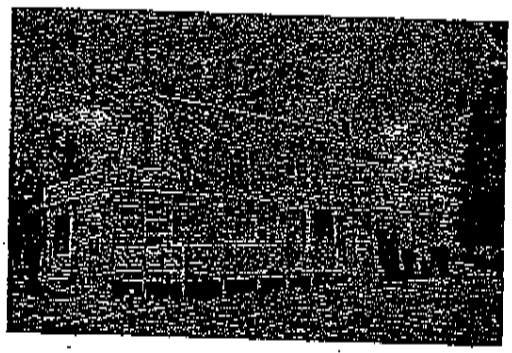
Lastly, we acknowledge the assistance and cooperation of the homeowners who permitted us access to their homes and agreed to temporarily relocate to allow the study to proceed. This work would not have been possible without their cooperation.

METHODS AND PROCEDURES

Selection of Homes

Mr. Richard Hatfield visited over a dozen homes, 10 of which were in the eastern Washington, northern Idaho area. The purpose of these visits included evaluating which homes might be available and suitable for testing. The primary criteria were the presence of Zonolite vermiculite used as insulation in the home. The homes needed to be available for sampling over approximately a 3-4 day period. The testing performed would not subject the occupants to any additional exposure to asbestos. The homes selected needed to have reasonable access to the areas (attics) where testing would be conducted. Homes having blown-in cellulose or mineral wool insulation, in conjunction with the Zonolite insulation were also not selected. The availability of electricity and water was also a criterion. Initially three homes met these criteria. One of these homes was later deemed not suitable since the family could only be relocated for 2-3 days.

View of Busch Home
1512 West 14th Avenue
Spokane, WA



View of Matthews Home
2207 South Adams Road
Spokane, WA

Selection of Activities

A series of teleconference meetings were held to plan the project and review the proposed study design. Possible activities to test were raised and discussed. The possibilities included cleaning activities, service work, maintenance work, remodeling work, renovation work, and demolition work. Home demolition was considered beyond the scope of this project, and a similar activity had already been studied by the Canadian government.[2] No activity was also considered, and selected, to provide a baseline for comparison with other activities to be tested. Long-term sampling in occupied homes was not considered feasible due to time and budgetary constraints. The criteria for the activities selected for testing were those activities that commonly occur in homes that might reasonably be expected to disturb in-place Zonolite insulation, or the dust/debris from that insulation. The activities selected were 1.) no activity, 2.) cleaning stored items

[2] Pinchon Environmental, *Final Report, Site Assessment, Vermiculite Removal, Building E-12, C.F.B. Shilo, Shilo Manitoba*, Report prepared for Department of National Defense, Base Construction Engineering, Canadian Forces Base Shilo, Shilo, Manitoba R0K 2AG, April 3, 1997.

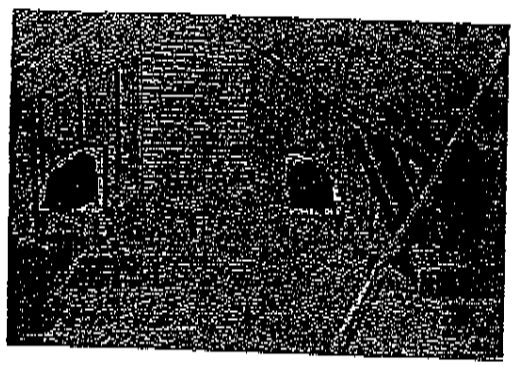
in an attic having Zonolite insulation at the perimeter only, 3.) cutting a hole in the ceiling of a living space with Zonolite attic insulation above, 4.) moving aside a known amount of Zonolite attic insulation using two different methods, and 5.) removing Zonolite insulation from the top of perimeter wall cavities with a shop vacuum.

Description of Activities Performed

Before conducting testing, the area where each activity would occur was separated from the rest of the house by erecting a two-stage decontamination station at the entrance to the attic or room. Each decontamination station consisted of two small rooms (approximately 4'x 4' separated by plastic flap doorways. The inlet for a high efficiency particulate air (HEPA) filtered vacuum was placed in the room closest to the work area. The decontamination station was designed to prevent activity-generated dust from migrating out of the attic or room. It also served as a location for persons to change out of personal protective equipment, wash, and clean equipment. As necessary, 4' suspended shop lights were installed to provide better lighting. Area sampling equipment, extension cords, tripods, and miscellaneous tools/supplies necessary to perform the tasks were brought into the area.

After the activity was performed, any items removed from the area were HEPA vacuumed and wet cleaned. Accessible Zonolite insulation in the attics of the two homes was removed by a state of Washington licensed asbestos abatement contractor (IRS Environmental, Inc., Spokane, WA). During and after the activities, area air sampling was conducted by a local consulting firm to determine if asbestos had migrated to occupied locations, or if the attics were clean after abatement (Fulcrum Environmental Consulting, Inc.).

Cleaning of Stored Items in an Attic with Zonolite at the top of Wall Cavities Only – This activity was perform in the attic of the Matthews home at 2207 South Adams Road in Spokane, WA. In this home the Zonolite insulation was limited only to the perimeter (primarily the east and west sides) of the attic space at the top of the wall cavities. The cleaning activity was performed by one individual with an assistant to help move trunks and boxes. The cleaning consisted of dusting the top surfaces of stored boxes (approximately 8), trunks (2), and fishing tackle with new cotton cloths and sweeping exposed wood floor areas with a corn broom.[3] Rugs on the attic floor were cleaned with a standard upright vacuum cleaner.[4] These procedures were performed in a manner described by the homeowner. The homeowner reported the attic had last been cleaned



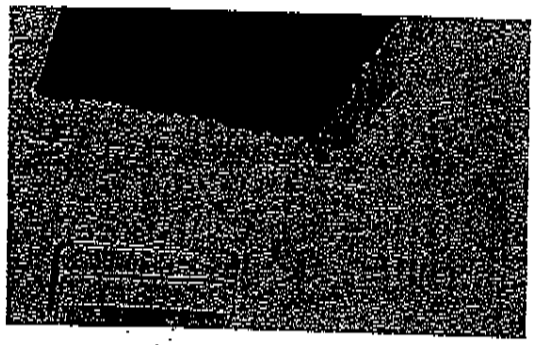
View of Attic Area Cleaned

[3] Harper brand, model No. 100, Harper Brush Works, Fairfield, IA 52556

[4] Eureka brand Upright Vacuum Cleaner, Household Type, Model No. 7600, The Eureka Company, Bloomington, IL 61710

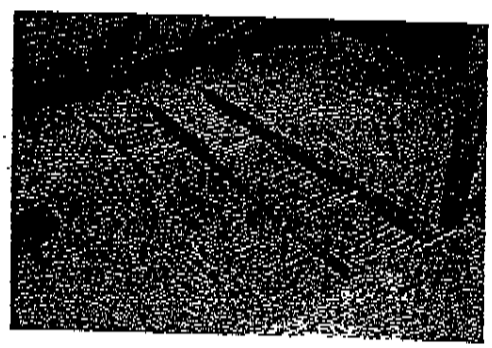
two years prior to this work. Approximately one half of the attic floor area was cleaned, or approximately 390 ft.^{2} The cleaning activity took 31 minutes to complete (in the order performed, sweeping-1 minute, dusting-13 minutes, vacuuming-17 minutes).

Cutting a Hole in the Ceiling of a Living Space Below Zonolite Attic Insulation – This activity was performed at the Busch home located at 1512 West 14th Avenue in Spokane, WA. The activity was performed by one person who cut an opening in the ceiling measuring 15"x 24" in a room measuring 11'2"x 13'4", with the assistance of a second person. The ceiling material itself consisted of a stipple finish on 1/4" wallboard, one layer of wallpaper, finish hard plaster, and a coating of gray hard plaster, on wood lathe. The area in the attic above the cutting location was inspected for electrical wiring as a safety precaution. The cutting was started by drilling a 2" diameter hole at one corner of the rectangle to be cut with a power drill equipped with a keyhole saw bit. The remainder of the cutting was performed with a Stanley brand 12" hand operated compass saw.[5] The entire cutting activity took 24 minutes to complete (in the order performed, drilling starting hole – <1 minute, remainder of time hand sawing with periodic short rest breaks). The average depth of Zonolite insulation above the cutout area was 4 inches.



View of Ceiling After Cutting

Moving Aside Zonolite Attic Insulation (Grace Method[6]) – This activity was performed in the attic of the Busch home located at 1512 West 14th Avenue in Spokane, WA. The floor square footage of the attic was 756 ft.^{2} (28'x 27'). This activity was performed by one person with the assistance of a second. The activity consisted of removing approximately 15 ft.^{2} (2'6"x 6') of Zonolite attic insulation having an average depth of 5" from between the floor joists. This material was misted with water using a hand held pump-up garden sprayer immediately before the work began. The Zonolite was scooped from between the floor joists and into plastic bags using a plastic dustpan. The remaining visible dust and debris was removed using a

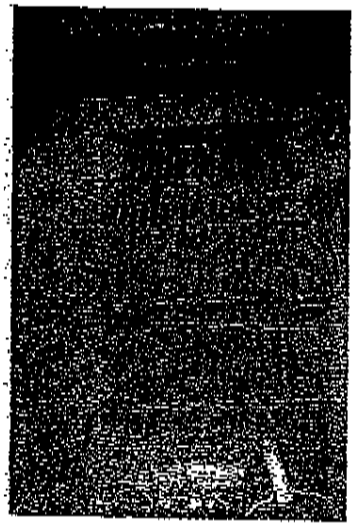


View of Zonolite in Attic after Moving by Grace Method

[5] Both the keyhole saw and the compass saw were 8 point saws, having 8 teeth to the inch.
[6] In re: W.R. Grace & Co., et al., Debtors (Case No. 01-01139), U.S. District Bankruptcy Court for the District of Delaware; Debtors' Answers and Objections to ZAI Claimants' First Set of Interrogatories to Debtors, Answer to interrogatory no. 27, August 23, 2002.

new HEPA filtered vacuum cleaner.[7] The activity took 33 minutes to complete (in the order performed, 2 minutes – misting with water, 25 minutes – scooping Zonolite into plastic bags, 6 minutes – HEPA vacuuming).

Moving Aside Zonolite Attic Insulation (Homeowner Method) – This activity was performed in the same attic as the previous test.. The activity consisted of removing approximately 14.4 ft.^{2} (2'8"x 5'5") of Zonolite attic insulation having an average depth of 5" from between the floor joists. The work was performed using the same methods except the Zonolite was not misted with water at the start of the work and a whiskbroom and plastic dust pan was used to remove the visible dust and debris at the end of the work.[8] The work took 29 minutes to complete (in the order performed, scooping Zonolite into plastic bags – 15 minutes, whiskbroom to clean dust and debris – 14 minutes).



View of Zonolite in Attic after Moving by Homeowner Method

View of Zonolite at Top of Wall Cavity Before Shop Vacuum Removal

Removal of Zonolite Insulation From the Top of Wall Cavities with a Shop Vacuum – This activity was performed in the attic of the Matthews home at 2207 South Adams Road in Spokane, WA. The removal activity was performed by one individual with an assistant. The work consisted of removing approximately 60 linear feet of Zonolite insulation from a trough at the perimeter of the attic having an average width of 5.5" and depth of approximately 4". The equipment used to remove the Zonolite was a standard shop vacuum.[9] The work took 44 minutes to complete, and consisted of vacuuming up Zonolite until the shop vacuum was about half full (approximately 3 gallons) and

[7] Ridgid brand, model no. WD09350 (9 gallon) manufactured by Emerson Electric Co., with a Trapmax 3 model no. VF6000 HEPA filter rated at 99.97% efficient down to 0.3 microns installed.
[8] O Ceder brand corn whiskbroom, 10" long , bristle spread 8" by 1"
[9] Ridgid brand, model no. WD0620 (6 gallon) manufactured by Emerson Electric Co., with part no. VF4000 filter installed.

dumping the contents into a plastic trash bag. The shop vacuum was emptied 7 times during this work activity.

Personnel Protection – Prior to the start of any field work, and again at the work sites all personnel were briefed on the project and the known health and safety hazards likely to be encountered. During the testing, any persons entering the attics or other work areas were required to wear respiratory protection and two layers of full body protective clothing. Full-face powered-air purifying respirators equipped with P-100 filters approved by the National Institute for Occupational Health and Safety (NIOSH).for use against asbestos. Personnel decontamination was performed on site through the use of a HEPA filtered vacuum followed by wet washing. A first aid kit was available for use as needed. No accidents or injuries occurred during the project.

Sampling Methods

Air, dust and bulk samples were collected as part of this project. The methods used were all routinely employed by the study team. No special training or new sampling methods were necessary. For all samples, sample logs and chain-of-custody forms were completed. Air, dust and bulk samples were stored and transported separately to minimize the opportunity of cross-contamination between samples. The methods employed are described below.

Amphibole asbestos species identified by electron microscopy or polarized light microscopy in air, dust or bulk samples are reported herein as "Libby amphiboles." The Libby amphiboles consist of fibrous tremolite, richterite, winchite, and actinolite.[10,11]

Air Sampling and Analyses

Personal and area air sampling was conducted. Personal samples were collected in the breathing zone of the person, but outside the full-face respirator. The personal samples were secured to the full-face respirator at approximately eye level so the sample would not be located in the exhaust of the powered-air respirator. The filter cassettes were positioned at approximately a 45-degree angle pointed downward. Personal samples were collected using battery-operated air sampling pumps calibrated before and after each set of samples during an activity.[12] Area samples were collected using electric air sampling pumps.[13] All personal sampling pumps were calibrated on-site using a primary flow

[10] For additional information on the nomenclature, see Wylie, Ann G. and J.R. Verkouteren, Amphibole Asbestos from Libby, Montana; Aspects of Nomenclature, American Mineralogist, Vol. 85, pp. 1540 – 1542 (2000).

[11] For additional information on the chemical and physical properties of Libby amphiboles see Meeker, G.P., et. al., The Chemical and Physical Properties of Amphibole from Libby, Montana: A Progress Report, U.S. Geological Survey, USEPA Health Effects of Asbestos Conference, Oakland, CA, May 24-25, 2001.

[12] Mine Safety Appliance (MSA) brand model ELF sampling pumps and one MSA brand model Flowlite pump.

[13] Dawson brand Gast electric pumps

meter.[14] Area sampling pumps were calibrated on-site using a precision rotometer. The rotometer was last calibrated on September 30, 2002 against a bubble meter.

Personal samples were collected in pairs. One sample was collected on a mixed cellulose ester (MCE) membrane filter (25 mm diameter) having a pore size of 0.8 micrometers (μm). The other sample in the pair was collected on the same type of filter with a pore size of 0.45 μm. Personal samples were typically collected at flowrates between 0.5 and 1.0 liters per minute (l/min.) due to the dusty environment anticipated. Area samples were typically collected at flowrates of 7 – 10 l/min. in non-dusty environments and 2-4 l/min. in dusty environments.

During the testing, the personal and area air sample filters were visually inspected at least every 5 minutes to estimate dust loading. The sampling filters were changed whenever there was a visible discoloration of the filter surface to reduce the chance of excessive dust loading on the filters. Blank samples were collected at a rate of 10 percent or two per sampling batch, whichever was greater.

All air samples were submitted to Materials Analytical Services, Inc. (MAS) in Suwanee, Georgia for analyses. MAS is accredited by the American Industrial Hygiene Association (AIHA) and the National Voluntary Laboratory Accreditation Program (NVLAP) administered by the National Institute of Standards and Technology (NIST). Personal air samples collected on 0.8 μm pore size MCE filters were analyzed by phase contrast microscopy (PCM) as described in NIOSH method 7400.[15] Personal and area air samples collected on 0.45 μm MCE filters were analyzed by transmission electron microscopy (TEM) using the direct preparation techniques described at 40 CFR 763, Subpart E, Appendix A.[16] The results of the PCM samples are reported as fibers per cubic centimeter of air sampled (f/cc). The results of the TEM samples are reported as structures per cubic centimeter of air samples (s/cc).

Dust Sampling and Analyses

Surface dust samples were collected as part of this study. Most samples were collected using ASTM method D 5755, Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentrations. This method uses a sampling pump calibrated at 2 l/min. to vacuum dust onto a 0.45 μm pore size MCE filter from a measured surface area of typically 100 square centimeters (cm^2). These samples were analyzed by TEM as described in ASTM D 5755 and results reported as asbestos structures per square centimeter of surface area sampled (s/cm^2). Three additional surface samples were collected from a surface using 3M brand post-it notes and archived for possible future analyses.

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[14] Bios International Corp., DryCal DC-Lite Primary Flow Meter (S/N 6615).
[15] Issue 2, August 15, 1994.
[16] This method is commonly referred to as the EPA AHERA method.

Table 1. Summary of Air Sampling Results for Cleaning of Stored Items with Zonolite at the top of Perimeter Wall Cavities Only

Sample Location	N	PCM	TEM	
		(f/cc)	(s/cc)	(s/cc > 5μm)
Worker, personal	3, 3	1.54	<0.42	<0.42
Assistant, personal	3,3	0.53	<0.33	<0.33
Area, in cleaning area	3	-	0.12	0.11
Area, adjacent cleaning area	3	-	0.07	0.07
Area, ~10 feet away	3	-	0.06	0.06
Area, ~20 feet away 3	3	-	<0.05	<0.05
Area, before cleaning	4	-	<0.002	<0.002

Before the cleaning activity began 4 dust samples were collected from 4 non-porous attic surfaces. The results ranged from not detected to 38,000 s/cm^2, with an average (logarithmic mean) of 9500 s/cm^2. Three bulk samples of Zonolite collected from the attic perimeter were analyzed by PLM and found to contain a "trace" of Libby amphiboles, by volume.[18]

Just prior to the cleaning activity 4 sheets of aluminum foil were placed on surfaces to collect dust settling during a 23 hour period. The locations ranged from about 10 – 20 feet away from the cleaning activity so they would not need to be disturbed during the activity. No asbestos structures were found in the 4 dust samples collected from the foil sheets. Values of less than 300 s/cm^2 are reported for each sample.

This cleaning study highlights a short-coming in two commonly used air sampling methods when employed to measure fibers or asbestos structures in a "dusty atmosphere." The direct preparation TEM method requires that small sample volumes be collected to prevent overloading of the filter surface. Where the dust collected is predominantly asbestos, this is not a problem. Where the dust collected is predominantly not asbestos, the non-asbestos dust obscures the asbestos structures. The result is a higher than desirable sensitivity. For the PCM samples, the non-asbestos fiber content of normal house dust (primarily cellulose fiber) provides for a high fiber count, when only a fraction of those fibers are asbestos.

For this study, the three area air samples collected in the cleaning area provide the best asbestos fiber exposure information for an individual cleaning stored items in an attic with Zonolite located in the perimeter wall cavities. These data indicate an average exposure of 0.12 s/cc during cleaning, a value 60 times higher than the background measurements collected in the same area before the cleaning activity.

[18] Note: a trace finding by PLM is an estimate of some value less than 0.1%.

Three bulk samples of Zonolite attic insulation were collected and each found to contain less than 1% amphibole asbestos by PLM. A bulk sample of the ceiling that was cut was also analyzed by PLM for asbestos. The ceiling consisted of wood lathe, hard plaster, finish plaster, 1/4 inch gypsum wallboard with wallpaper, and a stippled finish coat. Approximately 7% chrysotile asbestos was found in the stippled finish coat. No asbestos was found in the other materials. Accordingly, the ceiling system material cut was less than 1% chrysotile.

Cutting a plaster/wallboard/wood ceiling is a dusty operation. The PCM method of measuring fiber concentrations in such an atmosphere is not a good predictor of asbestos exposure, The TEM data provides the best exposure information in this instance since the method can distinguish between asbestos and non-asbestos structures. The use of the direct TEM method to measure asbestos in an atmosphere with considerable non-asbestos dust remains a concern.

From these data it may be concluded that persons cutting a hole into a ceiling below Zonolite insulation will be exposed to significant concentrations of amphibole asbestos. The worker exposure was measured at over 100 times the background samples collected before the activity.

Moving Aside Zonolite Attic Insulation Using the Grace Method

Before moving any Zonolite attic insulation 3 area air samples were collected for TEM analyses. No asbestos structures were detected in these samples. A value of less than 0.002 s/cc is reported.

Personal samples were collected on the worker and the assistant during the activity. Four sequential samples were collected to prevent overloading of the filters for each sample set. Three sets of 4 area samples (12 total) were collected during this activity. The worker exposure was measured by 4 PCM samples and 4 TEM samples. For the assistant, the PCM and TEM analyses were performed on the same filters since the TEM filters were voided due to a pump malfunction (crimped sampling tube).

The PCM results for the worker ranged from 4.61 f/cc to 16.24 f/cc, with a 34 minute TWA of 12.5 f/cc. The PCM results for the assistant ranged from 2.29 f/cc to 4.25 f/cc, with a 34 minute TWA of 3.12 f/cc. The TEM results for the worker ranged from 1.01 s/cc to 10.6 s/cc (1.01 s/cc – 8.58 s/cc, greater than 5 μm), with a 34 minute TWA of 6.29 s/cc (4.85 s/cc, greater than 5 μm). The TEM results for the assistant ranged from 4.35 s/cc to 6.42 s/cc (1.16 s/cc to 4.67 s/cc, greater than 5 μm), with a 34 minute TWA of 5.50 s/cc (2.74 s/cc, greater than 5 μm).

The TEM results for the 3 sets of area air samples as 34 minute TWAs were 3.78 s/cc (set 1), 1.86 s/cc (set 2), and 1.25 s/cc (set 3). Considering only structures greater than 5 μm, the 34 minute TWAs were 3.17 s/cc (set 1), 1.48 s/cc (set 2), and 0.90 s/cc (set 3). The results for all the area and personal samples are summarized in Table 3.

Table 3. Summary of Air Sampling Results During Moving Zonolite Attic Insulation Using the Grace Method

Sample Location	N	PCM	TEM	
		(f/cc)	(s/cc)	(s/cc > 5μm)
Worker, personal	4,4	12.5	6.29	4.85
Assistant, personal	4	3.12	5.5	2.74
Area, sample set 1	4	-	3.78	3.17
Area, sample set 2	4	-	1.86	1.48
Area, sample set 3	4	-	1.25	0.90
Area, before activity	3	-	<0.002	<0.002

Moving Aside Zonolite Attic Insulation Using the Homeowner Method

A set of 3 background samples were collected from the attic before starting the activity. No asbestos structures were detected on these samples, and an average of <0.003 s/cc reported. The same sampling protocol was followed as was performed when moving the Zonolite using the Grace method.

The PCM results for the worker ranged from 9.48 f/cc to 18.81 f/cc, with a 31 minute TWA of 14.4 f/cc. The PCM results for the assistant ranged from 0.64 f/cc to 10.4 f/cc, with a 32 minute TWA of 4.98 f/cc. The TEM results for the worker ranged from 11.8 s/cc to 29.1 s/cc (10.5 s/cc to 22.0 s/cc, greater than 5 μm), with a 31 minute TWA of 20.0 s/cc (16.0 s/cc, greater than 5 μm). The TEM results for the assistant ranged from < 0.53 s/cc to 5.92 s/cc (<0.53 to 5.92 s/cc, greater than 5 μm), with a 32 minute TWA of 2.99 s/cc (2.51 s/cc, greater than 5 μm).

The TEM results for the 3 sets of area air samples as TWAs were 1.20 s/cc (set 1 – 28 minutes), 2.00 s/cc (set 2 – 39 minutes), and 3.85 (set 3 – 39 minutes). Considering only structures greater than 5 μm, the TWAs were 1.06 s/cc (set 1), 1.57 s/cc (set 2), and 2.93 s/cc (set 3). The results for the air samples are summarized in Table 4.

concentration of asbestos. No asbestos was detected in these samples and values of less than 0.0016 s/cc are reported.
Personal samples were collected on the worker and the assistant during the activity. Four sequential samples were collected to prevent overloading of the filters for each sample set. Four sets of 4 area samples (16 total) were collected during this activity. The worker exposure was measured by 4 PCM samples and 4 TEM samples. For the assistant, the PCM and TEM analyses were performed on the same filters since the TEM samples were voided due to a pump malfunction (crimped sampling tube).

The PCM results for the worker ranged from 1.19 f/cc to 5.28 f/cc, with a 46 minute TWA of 2.90 f/cc. The PCM results for the assistant ranged from 1.47 f/cc to 4.81 f/cc, with a 46 minute TWA of 2.90 f/cc. The TEM results for the worker ranged from 1.05 s/cc to 2.16 s/cc (0.58 s/cc to 1.32 s/cc, greater than 5 μm), with a 46 minute TWA of 1.47 s/cc (0.98 s/cc, greater than 5 μm). The TEM results for the assistant ranged from 0.67 s/cc to 2.15 s/cc (<0.67 s/cc to 1.79 s/cc, greater than 5 μm), with a 46 minute TWA of 1.69 s/cc (1.10 s/cc, greater than 5 μm).

The TEM results for the 4 sets of area air samples as TWAs were 0.52 s/cc (set 1 – 43 minutes), 0.67 s/cc (set 2 – 42 minutes), 0.89 s/cc (set 3 – 42 minutes), and 1.00 s/cc (set 4 – 45 minutes). Considering only structures greater than 5 μm, the TWAs were 0.37 s/cc (set 1), 0.45 s/cc (set 2), 0.57 s/cc (set 3), and 0.73 s/cc (set 4). The results for the air samples are summarized in Table 5.

Table 5. Summary of Air Sampling Results During Removal of Zonolite Insulation with a Shop Vacuum from the Top of Wall Cavities

Sample Location	N	PCM	TEM	
		(f/cc)	(s/cc)	(s/cc > 5μm)
Worker, personal	4,4	2.90	1.47	0.98
Assistant, personal	4	2.90	1.69	1.10
Area, sample set 1	4	-	0.52	0.37
Area, sample set 2	4	-	0.67	0.45
Area, sample set 3	4	-	0.89	0.57
Area, sample set 4	4		1.00	0.73
Area, before activity	4	-	<0.002	<0.002

Just prior to the removal activity, 4 sheets of aluminum foil were placed on surfaces to collect dust which might settle during the activity and for a period of 20 – 33 minutes following completion of the activity. The total collection time was 65 - 78 minutes. The individual results are found in Appendix B (samples MD – 10 through MD – 13). No structures were found in two of the samples (<300 s/cc reported). The other two samples found 300 s/cm^2 and 700 s/cm^2 of amphibole asbestos.[19] The data, when viewed together

[19] Note: a longer settlement time was not possible as the remediation contractor needed access to begin their work

with the area air sampling, indicate an hour would not be a sufficient settling time before starting a clean-up.
The worker and the assistant exposure data were very similar for this study. The likely cause is the worker and assistant worked together to dump the Zonolite from the vacuum into plastic bags. This was visually a dusty operation. The vacuum was equipped with a standard pleated filter which, while not HEPA rated, likely captured much of the dust generated.

The data from the use of a standard shop vacuum to remove Zonolite insulation demonstrates this activity results in significant exposure to amphibole asbestos. The worker exposure for this study was found to be 735 times the background samples collected before the activity began.

Miscellaneous Observations

The background samples collected in the attics of the two houses indicated that absent any disturbance, there was not an elevated concentration of asbestos in the air. Similar sampling should be conducted in homes during high wind storms. Anecdotal information from at least one homeowner indicates that some Zonolite insulation is blown out from wall cavities under certain circumstances.

During the cleaning, and removal with shop vacuum studies, area air sampling was also conducted in the living space of the home. The purpose of the sampling was to verify the effectiveness of the containment. However, it also served to measure pre-existing airborne asbestos concentrations. The results indicated the pre-existing airborne concentration was not elevated.

Two area air samples were also collected outdoors of the two homes. The analyses, found in Appendix A, did not detect any asbestos.

A total of 17 blank samples were collected and analyzed as part of the study. These blank samples were handled and analyzed in the same manner as the field samples. The results of these samples, included in Appendix A, demonstrate there was no systematic contamination of the field samples.